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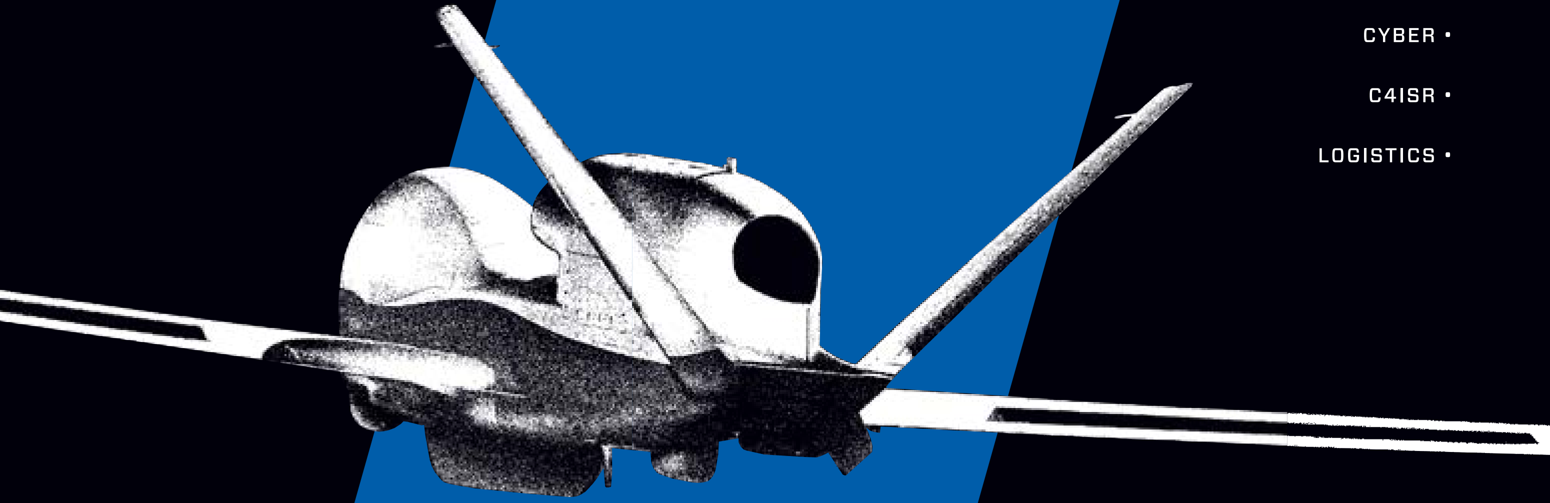

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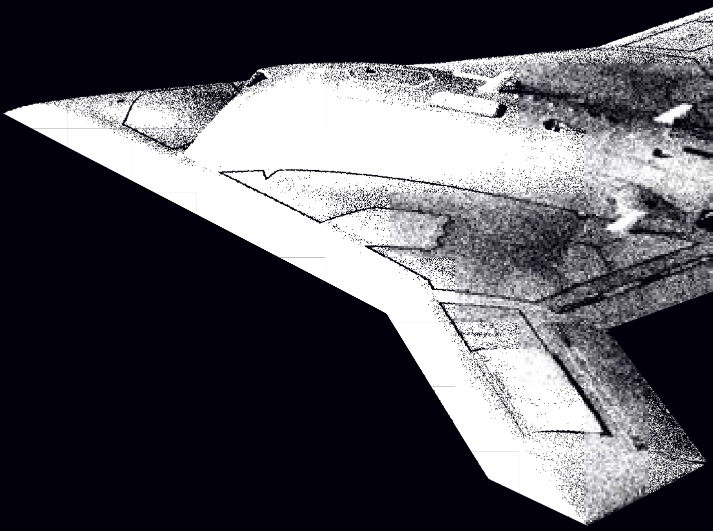

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Front cover: MALE UAS will see a range of new roles in the post-Afghanistan landscape, with developers needing to respond to emerging requirements. *(Photo: GA-ASI)*

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The snowball effect

This time 14 years ago, I was mid-way through the initial sizing of a HALE UAV for my final-year project at the University of Southampton. Armed with a copy of Daniel P Raymer's *Aircraft Design: A Conceptual Approach*, I locked myself in the spare room of my parent's home to escape the festive noises from downstairs, entering the author's complex sizing equations into Microsoft Excel. I recall saving the files onto floppy disc – yes, that's how long ago it was.

OK, so it wasn't my most exciting Christmas, but I nailed down the key parameters for my design, adjusting them based on future expectations in UAV design – this was interesting. However, Raymer's book gave multipliers for some of the equations that were based on manned aircraft, so I had to tweak these and justify their use by basing them on the foreseeable developments in unmanned vehicles.

I recall writing that my design should be capable of being built, with certain provisos. What prompted me to design a UAV in the first place was reading an article about the capabilities of the Global Hawk, where I was amazed by what it could do. Little did I know then about just how big a role this platform would go on to take in operations today.

But technology snowballs and having just taken on the editorship of this magazine, I'm fascinated by where we currently are. Somehow the unmanned vehicle concepts that I read about back in 2000 have now come to fruition and in many ways have surpassed expectations – not just mine, but the entire industry's.

This is something to be celebrated, so I can completely sympathise with the industry leaders that attended the Commercial UAV Show in London in October and were upset by the FAA's comments that the sense and avoid technology 'hasn't proven to exist'.

While the US military might not have a solution, there clearly are numerous companies throughout the world that do and you can read about who they are on p22. I'll point you to Michael Drobac's concluding comment about overcoming adversity – if his words don't spur you forward, then I don't know what else will.

Elsewhere in the issue we have two new data links coming onto the market (see p32), with Peter Donaldson exploring what they offer. We also look at the new technology being used in UGVs and the direction they are taking, with Andrew White picking out some inspiring examples. My favourite involves inspecting underneath pipelines – somewhere UAVs cannot see.

We've also looked how unmanned vehicles are increasingly being used for environmental monitoring (see p17). Kongsberg Maritime's Seaglider, for example, can monitor the oceans for as long as nine months and uses small changes in buoyancy and wings to move forward. It pitches and rolls using adjustable ballast – very clever.

Finally, we saw a similar example of cleverness in December when NASA's Predator B, Ikhana, monitored the Orion space capsule (see p4). It not only helped the US Navy retrieve the capsule more quickly, which will be important when there are astronauts in it, but allowed the whole world to watch live online.

The take-home from all of this is that while the big money might be with helping the military strike targets, those of us looking at the scientific and practical applications of unmanned vehicles may well be the ones that strike gold.

Daniel Tye, Editor

RESPONSE

Unmanned Vehicles' editorial team is always happy to receive comments on its articles and to hear readers' views on the issues raised in the magazine. Contact details can be found on p1.

IN THE NEXT ISSUE

- Weapon integration
- Cargo-carrying UGVs
- Airspace integration
- Flight control systems

ARCA Space's Explorer and Pioneer UAVs begin flight testing on US soil

ARCA SPACE

ARCA Space says its two new AirStrato 'aerial robots' have 'the flight ceiling of the Global Hawk, the endurance and the size of the Predator and the payload of the Shadow'.

The claims were made as the Romanian company starts flight testing its Explorer and Pioneer models on US soil, in New Mexico.

ARCA is looking to sell these platforms to small businesses, research institutions and even individuals. It might well achieve this too, as prices start from $140,000 for the Explorer and $80,000 for the Pioneer. Pre-ordering has opened up, with the company offering significant price reductions until production starts in the US – May for the Pioneer and August for the Explorer.

While both models carry the same 45kg payload, Explorer is the larger of the two and has a 20-hour endurance with a ceiling of 60,000ft, compared to Pioneer's 12-hour endurance and ceiling of 26,000ft.

Both launch from a runway using electric propellers mounted on the trailing edge of the wings, but one of the key points the company highlights is that they can launch from a pneumatic catapult (called the Accelerator, which costs $20,000). When operated in this way, the AirStrato recovers by parachute.

The sales pitch is that these UAVs give users the chance to operate a MALE/HALE platform that won't bust the budget. Both use solar power to keep operating costs low, something that will prove attractive to civil/commercial outfits or universities. ARCA is positively upbeat about the opportunity these aerial robots are offering.

'This product fills a huge gap between expensive, large military UAVs and less expensive, small-scale civilian commercial drones by combining the performance of the former with the price of the latter,' the company states.

By Dan Tye, London

Predator B warbird turns science geek

NASA/CARLA THOMAS

While the Predator B is a feared adversary in conflicts, it also performs well in science experiments.

NASA's version, called Ikhana, was tasked with loitering over the sea to monitor the Orion capsule as it returned to Earth after its 4.5 hour orbital flight in December.

Ikhana's IR cameras followed the heat signature of the rocket as it launched, while its optical cameras streamed live video of the Delta IV Heavy rocket to millions around the world watching online. The UAV then picked up the action later for the Orion capsule's re-entry into the Earth's atmosphere using IR.

It also filmed its splashdown into the sea and helped NASA's operators direct US Navy vessels to recover it. Throughout this, NASA engineers were studying Ikhana's ability to loiter and keep watch over a monotonous landscape.

The system made the headlines across many different types of news outlets, largely because of its use for science instead of war.

NASA's previous forays into using military UAVs for science has been overlooked, but in 2013 the administration flew such systems into an active volcano to study the effects of volcano-specific smog.

As for Ikhana, she deployed over the Hawaiian Islands in August 2014 to test new systems that may allow her to fly science missions into the extreme cold of the Arctic Circle egion.

Ikhana is a Native American Choctaw word meaning 'intelligent, conscious or aware', and she is living up to her name so far.

By Dan Tye, London

Bulgaria purchases UAV Solutions Phoenix 30 VTOLs

Bulgaria's military will be pleased with the speed of response for its four new Phoenix 30 UAVs. The country asked the US Army to put out an RfI for a 10lb (4.5kg) VTOL solution in July and the Phoenix 30 quad-rotors were delivered by UAV Solutions in December – just six months later.

The Bulgarian armed forces have not stated the intended purpose of the systems, but Bill Davidson, CEO and chief engineer of UAV Solutions, said the platform is a 'competent intelligence, surveillance and reconnaissance platform that will assist them with their operations'.

The RfI, however, gives some insight into how they will be used. The Bulgarians asked for the ability to fly all four at once in all-weather and to have two choices of payload – either a 10x optical zoom video camera or a thermal imaging payload.

UAV SOLUTIONS

GPS camera targeting and real-time digital video were also listed as 'must-haves'.

The Phoenix is 510x510mm, weighs 4.5kg and takes only a few minutes to deploy. Endurance is 25-30 minutes depending on the mission profile. UAV Solutions will be teaching the Bulgarian military how to operate the platforms in mid-2015.

By Dan Tye, London

Swedish Navy to trial APID 60 VTOL

The Swedish Navy will be trialling CybAero APID 60s from a *Visby*-class corvette this year, as the case to use the type in a maritime role strengthens.

The company's efforts to push this systems into this domain appear to be paying off, as China Customs, its first maritime application customer, is due to receive its units shortly.

This latest request from the Swedish Navy is good news for CybAero. CEO Mikael Hult said: 'Now that we have been chosen by FMV to conduct the test and demonstration flights, we have a great opportunity to put our systems on display and this will serve as a good reference point for potential clients in Sweden and abroad.'

While the US Navy is about to start flying its MQ-8C Fire Scout (an unmanned Bell 407 helicopter) from its ships, it seems the Swedes and the Chinese might be onto an attractive solution at a lower price – the APID 60 can carry a payload of up to 50kg in difficult maritime conditions, including poor visibility and strong winds, up to 200km away.

The UAS carries a range of sensors including video camera, IR thermal imaging camera, jammer, microwave radio equipment, biochemical sensors, laser scanner and ground radar – plenty of capability from a relatively small size.

By Dan Tye, London

CYBAERO

On the web

Aero Surveillance unveils ASV100 VTOL UAS
9 December 2014

Corsair upgrading UAS trainer for quadcopters
2 December 2014

US airspace gradually opening up to UAS
21 November 2014

Patroller UAS completes ODREA flight tests
21 November 2014

Leidos runs at-sea testing for autonomous vessel prototype
19 November 2014

Northrop Grumman to continue Global Hawk sustainment
13 November 2014

Swedish FMV orders Falcon ROVs for Swedish Navy
12 November 2014

Domestic aerostats aloft in Zhuhai
12 November 2014

UCAV revealed in PLAAF colours
12 November 2014

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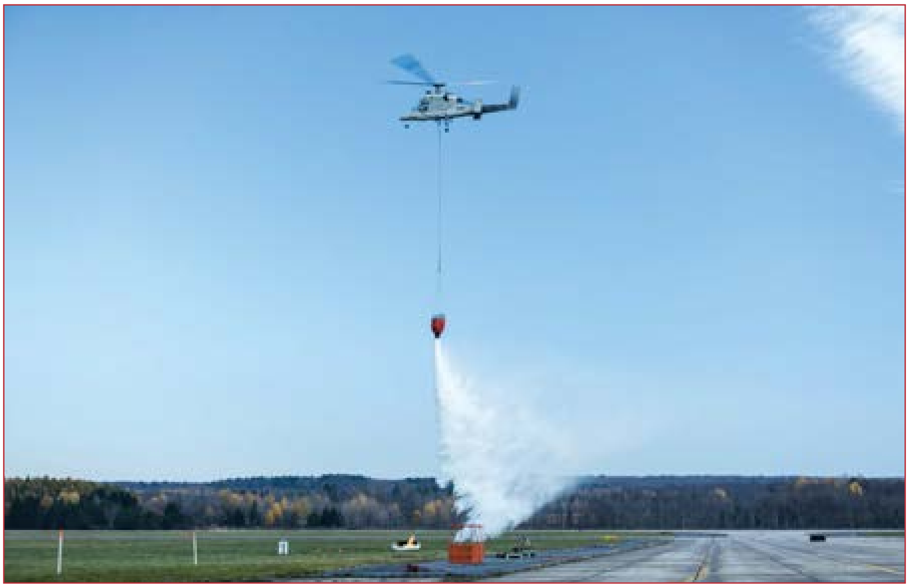
K-MAX system douses its first fire



LOCKHEED MARTIN

It has already proven itself in combat in Afghanistan and now the K-MAX has just demonstrated its potential for fire-fighting.

Lockheed Martin told *Unmanned Vehicles* at Euronaval in October that it would carry out a fire dousing exercise with K-MAX and this went ahead on 18 November at Griffiss Air Force Base in New York. The aircraft was fitted with a custom-made Bambi Bucket and successfully lifted and dropped more than 659l of water to extinguish a small fire in an oil drum on the base. The exercise also proved the concept of Lockheed Martin's 'fire-seeking' UAS called Indago, which was used to initially locate the fire using its onboard EO/IR sensors. The position of the fire was then passed to the K-MAX's operator.

The K-MAX has its own EO/IR sensor, but the idea behind Indago is that fire chiefs can send this in first through thick smoke and even through a fire without risking the platform. The Indago will be able to understand the situation, pass information back and then operators can decide how to fly the K-MAX to put the fire out.

The water bucket has been specially designed by SEI Industries so that it folds up and fits inside the K-MAX's cargo bay. As a result, flights to and from sites can be made without a bucket dragging underneath and ground crew no longer have to waste valuable time trying to locate the bucket.

More tests are due to continue throughout 2015.

By Dan Tye, London

US Navy starts testing 'bigger' Fire Scout

Sailors on board USS *Jason Dunham* will be the first to see the MQ-8C version of the Fire Scout flying off ship during the coming months.

While they will be used to seeing helicopters operate from deck, no doubt it will take some adjustment to get used to the converted, unmanned Bell 407 with sealed up windows, as the navy assesses it for operational use.

The manufacturer, Northrop Grumman, is under contract to build 19 MQ-8C Fire Scouts, with two of these being test aircraft. The US Navy plans to buy 70 of them if the shipboard trials prove successful.

While the navy has been using the smaller MQ-8B Fire Scout for some time, the larger airframe of the C variant means it can fly nearly twice as long and carry three times more ISR payloads than the 'B' – it appears that naval commanders may well be close to running operations with the intelligence-gathering capabilities they have been asking for.

NORTHROP GRUMMAN

By Dan Tye, London

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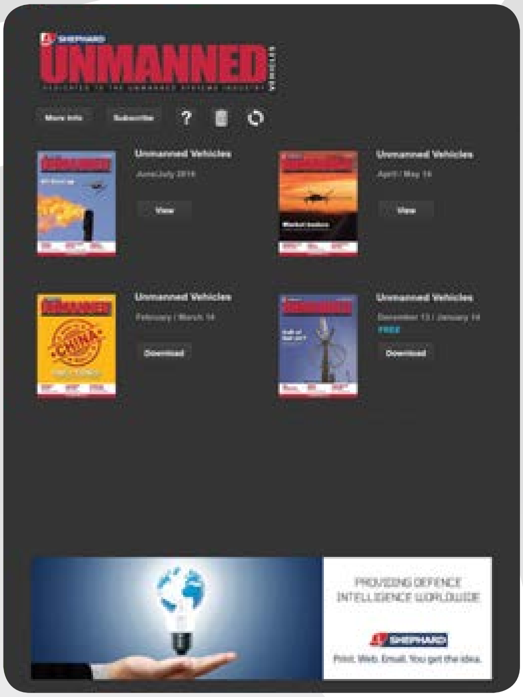

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MALE evolves

COMMONWEALTH OF AUSTRALIA

The Heron UAS provided high-resolution ISR imagery to ground commanders in Afghanistan

The requirements for and specifications of MALE UAS are evolving as militaries prepare their fleets for a post-asymmetric warfare environment. **Claire Apthorp** examines how industry is responding.

The past decade of operations in the Middle East has seen MALE UAVs flourish in the ISR space. As battlespace requirements evolve, however, the type's development is likely to move into a number of new areas beyond the counter-insurgency/-terrorism mission niche it has until now been fitted into.

Payload requirements will be defined by a much broader set of operational applications, moving further into the SIGINT, communications and networking areas, while the mission sets themselves will see the aircraft deployed increasingly in the maritime domain and higher-threat scenarios than witnessed in recent theatres. Additionally, MALE UAS will continue on the present trend towards the joint manned/unmanned operational space as a complement to existing platforms.

CRAWL, WALK, RUN

With future adversaries likely to include peer or near-peer armed forces, a number of programmes are under way around the world to develop unmanned aircraft capable of operating in contested airspace, with a focus on low-observable and high-survivability designs.

The US Navy's X-47B Unmanned Combat Air System (UCAS) Carrier Demonstration programme, for example, has been under way since 2007. The effort will help the service explore the future of unmanned aviation, examining how a carrier-based fleet of UAS will fit into the operational picture.

The tailless, strike fighter-sized X-47B has been designed and produced by Northrop Grumman, and the company is now involved in the flight test programme, with relevant launch, landing and integration technologies currently being matured.

In 2013, the aircraft conducted its first carrier-based catapult-launch from the deck of USS *George H W Bush* (CVN-77) at sea, followed by the first carrier-based touch-and-go landings and arrested landing at sea, both on CVN-77. This was followed by a further phase of carrier-based testing aboard USS *Theodore Roosevelt* (CVN-71).

TEST RESULTS

In August 2014, work progressed with a series of cooperative manned/unmanned flights from CVN-71 teaming the X-47B and an F/A-18 Hornet, in what marked the UCAV's fifth test period at sea.

'The first four test detachments focused on evaluating X-47B launch, recovery and deck handling operations in the absence of other carrier aircraft,' Capt Beau Duarte, Unmanned Carrier Aviation Program Manager (PMA-268), USN, told *Unmanned Vehicles*.

'In the "crawl, walk, run" philosophy, we demonstrated that we could crawl. The next step was to focus on evaluating the teaming capability of manned and unmanned aircraft, which is the way future operations will be conducted on the limited real estate of the carrier flight deck.'

The Northrop Grumman and navy team prepared for the test event by operating F/A-18s and the X-47B together on the runways at NAS Patuxent River, Maryland, rehearsing the carrier-based test scenarios. The tests successfully demonstrated that the UCAV could trap aboard the aircraft carrier and taxi clear of the landing area quickly enough to allow an F/A-18 to land immediately behind the X-47B with a fleet-representative aircraft recovery interval.

'This milestone accomplishment required the system of systems integration of X-47B deck handling, aircraft guidance and control, and aircraft-mounted navigation systems, in concert with the existing set of complex carrier-based landing and display systems already used to support basic carrier flight deck operations,' Duarte continued.

Sea Avenger is a proposed carrier-based derivative of GA-ASI's Predator C Avenger UAS

GA-ASI

'In addition, we conducted X-47B night flight deck operations to understand the human interface and suitability of the UAV and deck operator's handheld control unit in the night environment. Since the shipboard environment presents different challenges at night, this test was an incremental step in developing the operational concept for more routine UAS flight activity. Higher than expected workload resulted, which will inform future deck handling designs.'

RETURNING TO SEA

Based on lessons learned to date during the risk-reduction programme, the USN is currently continuing to investigate the feasibility of returning to sea to further refine the concept of operations for manned and unmanned aircraft working together. According to Duarte, that decision will be driven by carrier availability and funding resources, with no firm date set at the time of going to press to conduct another at-sea testing detachment.

'We've learned a lot, and will continue to learn – that's why we conduct experimental flight tests,' added Duarte. 'The navy's Unmanned Carrier Aviation Program Office continues to leverage findings from other naval UAV acquisition programmes and our sister services to feed into future programmes, such as Unmanned Carrier Launched Air Surveillance and Strike [UCLASS] capability.'

UCLASS aims to bring next-generation sea-based persistent, responsive and affordable long-range ISR and targeting and light strike capabilities by the beginning of next decade.

Four teams were awarded preliminary design review (PDR) contracts for the programme in August 2013 – Boeing, General Atomics Aeronautical Systems Inc (GA-ASI), Lockheed Martin and Northrop Grumman – with draft RfPs issued in April 2014.

While Northrop Grumman's design will be based on the X-47B, Lockheed Martin's Sea Ghost concept will leverage technologies from the F-35C and RQ-170 Sentinel. Boeing's bid is expected to be based on the X-45C prototype developed under its Phantom Ray programme – originally for the USAF/USN/DARPA Joint UCAS programme, while GA-ASI will offer a carrier-based derivative of its Predator C Avenger UAS, called Sea Avenger.

The final RfP has been delayed as the navy seeks to refine the balance of the aircraft's surveillance/strike requirements. The question for the navy is to determine whether it can sustain three separate surveillance capabilities – UCLASS, the MQ-4C Triton and P-8 Poseidon – or if it should focus more heavily on the strike requirements of the programme to augment combat capabilities.

AVENGER'S EVOLUTION

GA-ASI's offering is based around the anticipated requirements for a carrier-based UAS that is also capable of integrating into the carrier air wing. The aircraft design includes a fuel-efficient engine and inlet, retractable EO/IR sensor, internal weapons bay and folding wings. It also features a structure with the flexibility to accommodate carrier-suitable landing gear, tail hook, drag devices and other equipment required for carrier operations.

Sea Avenger is based on Predator C, which is capable of conducting high-speed,

➤

BOEING

Boeing's UCLASS bid is likely to draw on its X-45 Phantom Ray demonstrator

multi-mission persistent ISR and precision, time-sensitive strike missions over land or sea. With a 44ft-long fuselage and 66ft wingspan, it is capable of flying at 400kt for 20 hours, and can operate up to 50,000ft carrying up to 1,360kg of internal payload, a Lynx synthetic aperture radar and various EO/IR camera systems.

Unlike the concepts under development with the other programme contenders, GA-ASI remains committed to an ISR-focused airframe, something that is reflected throughout its MALE UAS platform development as it looks to the coming decade.

'For UCLASS, there are different philosophies in the navy, with some that want it to be a stealthy strike platform and others that want it to be persistent ISR – and it's probably going to be a compromise or hybrid between the two,' Chris Pehrson, director of strategic development at GA-ASI, told *UV*. 'Our offering is still toward the long endurance ISR, so while I wouldn't close the door on moving into the UCAV market, there's enough demand for what we are really competent at, and that's the long-endurance ISR platform.'

RIGHT PLACE, RIGHT TIME

Having the right technology and capability in place at the right time has been a key enabler of GA-ASI's success in the MALE UAV sector. The company's Predator A/Gray Eagle A-series aircraft family achieved three million flight hours in October, with nearly 222,000 missions completed and almost 90% of them flown in combat. A significant proportion of the company's development is focused on extending the range of its platforms across the board.

The OEM's Improved Gray Eagle (IGE) next-generation derivative of the Block 1 Gray Eagle, with a deeper fuselage for greater fuel capacity, external fuel tank provision and a larger engine to carry more payload, will have the potential to fly for close to 60 hours.

Predator B Extended Range (ER) – with several operational kits of a contracted total 38 already delivered to the USAF – has a maximum endurance with a clean wing of 37-38 hours. An additional ER variant is currently under internal R&D that will have a longer wing with more fuel capacity to increase endurance even further.

'We designed for persistence, and it's that long endurance that has been the key enabler for so many things the UAVs bring to the fight: the ability to persistently observe and collect pattern of life, as well as integrating the weapons and sensors delivering a very tight circle of detecting something and being able to act on it,' Pehrson said.

'The lesson is that we do very well in permissive environments where we own the airspace and there's no air or ground threat against the aircraft, and that freedom of action has allowed us to stay airborne for those long periods.'

AT THE HIGH END

Among the priorities for the US military has been the move towards high-end capability as operations in the Middle East draw down, as reflected in the UCLASS drive for stealth, airspace penetration and the ability to defeat near-peer competitors that have air defence capabilities. However, this shift is now less clear-cut.

'The latest changes with ISIS in Iraq and Syria have made them re-evaluate that somewhat, and there is still relevancy for persistence,' Pehrson said. 'We want to maintain that persistence while also enabling that high-end capability.

'So even if we aren't the one penetrating defences, we can enable other platforms such as fourth- and fifth-generation fighters as a communications relay, by extending their sensor web or as a truck carrying missiles and decoys so those stealthy platforms don't have to give up their position. Up until now the weapon and aircraft have been deployed as one mission, but I think the trend is moving toward networking, where UAVs are an extension of manned aircraft or vice versa.'

This will require improved open architecture and standards, but the demand is already emerging, as seen by the Gray Eagle and Apache manned/unmanned teaming being explored by the US Army. With the UAS able to be controlled from the cockpit of the helicopter, the Apache is able to hang back and let the UAS remain overhead to provide eyes on scene, and – potentially – designate and prosecute targets.

SEA CHANGE

The move into the maritime domain is currently dominated by HALE systems like the MQ-4C Triton. The USN's programme of record calls for a total of 68 aircraft to be fielded, with each capable of providing real-time ISR in maritime regions, covering up to 1 million square nautical miles of ocean during a single 24-hour mission.

MALE UAS that have taken part in high-intensity operations in the Middle East are playing an important role in helping armed forces explore how they will move into the HALE sphere. In March 2014, the Australian government confirmed that it would become the first export customer for the Triton UAS as part of a programme to boost the ADF's maritime surveillance powers.

The country's primary MALE UAS capability throughout the Afghanistan campaign has been provided under a service provision

The US Army has done a significant amount of work to develop manned-unmanned teaming operations

US ARMY

arrangement with MacDonald, Dettwiler and Associates (MDA) using the IAI Heron.

Originally due to return to Australia in mid-2014, the government elected in July to extend its deployment in Afghanistan until the end of 2014 to continue supporting ISAF ISR requirements. Furthermore, in late October the government announced that two Herons will be retained in Australia following withdrawal from Afghanistan in preparation for Triton's arrival.

A defence spokesperson told *UV*: 'Heron provides a capability that will remain relevant to Australian security even as we leave Afghanistan. It would be remiss of us not to continue to develop our knowledge of this technology to ensure we are able to provide the best protection for our troops on future defence operations. For this reason, the air force will return a limited Heron capability to Australia once the mission in Afghanistan ends.'

INVENTORY INCREASE

The capability will include: an additional Heron to join the one already based at Woomera; portable ground control stations initially based at Woomera and deployable to locations required for operations and training; all maintenance, logistics, support and training; and renovation of Number 5 Flight facilities at RAAF Base Amberley. The estimated cost is about $120 million over six years, and will be funded from within the existing air force budget through a redistribution of tasks and priorities.

'The Heron will provide opportunities for both training and the development of robust tactics, techniques and procedures for operating complex UAS platforms, including the integration of UAS technology into Australian airspace,' the spokesperson said. 'The Heron has provided the air force with experience and knowledge essential for the use of unmanned platforms in [the service's] future fleet.

'The operation of Heron over the next six years will ensure the retention and development of knowledge and skills until the introduction of future unmanned platforms, including the MQ-4C Triton.'

MALE UAS have earned their stripes in the Middle East, but their potential is only just beginning to be fully realised. While persistent ISR will continue to be a major draw, demand will increasingly see development focused on applying the technology to more varied mission sets, across maritime, strike, stealth and beyond. uv

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Stepping up

UGVs are beginning to find greater utility outside of the military sphere. **Andrew White** examines the future role of the platforms in disaster response, fire-fighting and CBRN work.

iRobot secured a $9.6 million contract to provide the Canadian DND with 20 510 PackBot UGVs enhanced for CBRN operations

IROBOT

The global UGV sector, valued at $1.51 billion in 2014, is due to grow to $8.26 billion by 2020, according to the latest report from MarketsandMarkets.

The trigger to set off this dramatic growth is claimed to be an increase in demand of 'non-defence applications and the UGV functionality to perform complex operations,' the report reads.

However, some leading players in the unmanned industry are questioning whether UGVs will experience the same impressive rise which has taken UAS much longer to complete.

According to Stephen Green, VP of business development at Textron Systems Unmanned Systems, UGVs face a different set of challenges than their aerial counterparts.

Speaking to *Unmanned Vehicles* at the Commercial UAV Show in London in October, he said: 'There are a different set of challenges [in UGV] missions and the sense that I get is it will be some time before that becomes a practical solution. When you're on the surface of the water or in the air, your ability to navigate is pretty straightforward. But when you're on the ground, you've got to overcome physical obstacles and navigational issues that are significantly more complex.'

uPoint allows standardised control of multiple vehicles in the iRobot family

IROBOT

GOOGLE DRIVE

Referring to efforts by Google to develop an autonomous car, Greene continued: 'They've done a lot of the races through the desert and they're talking about having to come up with algorithms that can recognise a rock or a bird in front of a car. This makes a difference to a ground vehicle because a rock won't move but a bird will, so there should be no need to slow down or manoeuvre out the way. There are all kinds of scenarios, but surface and air vehicles don't have that same construct and limitation.'

According to the MarketsandMarkets report, the UGV sector is dominated by the US (a 50% share), followed by Europe, with strong interest in France, Germany and the UK. Additionally, the report highlights China and India as growth markets in the Asia-Pacific region, with 'increasing defence spending and demand for tactical UGVs.'

It continues: 'The commercial applications specifically in industrial operations and surveillance are expected to drive the UGV market. Robots are also broadly used in the hazardous operations of disaster response, reconnaissance, reconstruction and rescue operations.'

Frost & Sullivan warns that the proliferation of UGVs over the next decade will remain limited, as it is yet to be confirmed how this technology will be best put to use. It concedes, however, that the commercial automotive industry is trailblazing the way.

A spokesperson said: 'Commercial vehicle manufacturers with a significant defence industry footprint may be able to migrate technology into military vehicles once costs are driven down through increasingly accessible commercial supply. Perhaps in five years semi-autonomous appliqué add-ons to vehicles will begin the transformative process thanks to commercial advancements.'

BUDGET RESPONSE

Speaking to *UV* at the AUVSI exhibition in Orlando in May, iRobot's EVP and CFO Frank Wilson explained: 'Everyone knows that the US defence budget has gone down, so we responded two years ago. We are active now in various segments including law enforcement, fire-fighting and industrial applications.'

Wilson added that the company was approaching a 50% split between its defence and commercial businesses, with the latter performing better in the international market in comparison to military sales.

Launched earlier this year, iRobot's latest commercial offering is the Ava 500 Video Collaboration Robot, a UGV-enabled video teleconferencing system. Designed to provide a 'physical presence' of an individual from a remote location with 'complete freedom of movement', the system includes a mobile platform with screen which can manoeuvre around an office for meetings and discussions, allowing workers who might be based in satellite offices to have easy access to board meetings and other events.

A spokesperson for the company said: 'We thought that this product would be mainly of interest for executives, as it saves costs and time in travelling. However we find that also engineers, for example, are interested so they can communicate with each other while working in different locations.'

MARKET INFANCY

According to Lockheed Martin unmanned systems business development director Don Nimblett, the civil UGV market remains in its infancy, especially in regards to vehicle types such as its Squad Mission Support System (SMSS).

Nimblett told *UV*: 'There are many small reconnaissance and bomb-disposal robots in use today, but their utility is limited in the roles SMSS fulfils [in logistics resupply]. The introduction of car- and truck-sized robotic vehicles is just beginning, but it is very promising and we anticipate fairly rapid growth in that market within three to five years.

'We anticipate that the immediate applications of this technology will be to vehicles in a transport role, but "roboticising" vehicles with functional applications, such as forklifts, scoop loaders and excavators, is beginning and should also grow rapidly in the coming years. In fact, precision agriculture is already well under way. Progress in these markets will depend upon affordability, reliability and acceptance by the various stakeholders in the successful introduction and application of robotic vehicles and systems.'

The SMSS is currently undergoing an evaluation as the 'Fire Ox' for fire-fighting applications, with a live burn demonstration scheduled in the near future.

'We anticipate that the fire-fighters participating in the exercise will employ the Fire Ox in various ways in order to experiment with it and determine its full capabilities,' continued Nimblett.

First, its 1,136l water tank could be filled from a hydrant, water tanker or fire truck and sent out to create a fire break with the use of sprayers mounted on the front of the vehicle, which would be employed as it is sent on a specified path to create the fire break.

A second concept would be to attach a long fire hose from a hydrant, water tanker or fire truck to a special connection on the Fire Ox and have the SMSS move out to a designated position, pulling the hose along. The platform could then begin attacking the fire, moving to where required, while receiving a virtually unlimited supply of water. As desired, a foam mixture could be introduced to the water spray to dampen down fire areas.

PLATFORM UTILISATIONS

'We are also looking at how SMSS can perform missions relating to site security and the patrolling of critical facilities, such as chemical and oil production/storage facilities, as well as nuclear power plants,' added Nimblett. 'We also see it performing in a mobile power role for disaster sites, providing electrical power for disaster rescue crews and facilities.'

He also noted that such a platform could be used to carry large drilling equipment or inspection loads.

Meanwhile, Tom Phelps, director for robotics products at iRobot, explained to *UV* how the greatest share of the commercial market comprises public safety and first responder organisations.

'Historically, where we have good market penetration and solidified customer base is ➤

LOCKHEED MARTIN

The SMSS is currently undergoing an evaluation as the 'Fire Ox' for fire-fighting applications

in the public safety market,' he said. 'We've had a lot of interaction with general police usage for suspicious devices and barricaded suspect hostage situations. Our product line is geared towards supporting public safety.'

Referring to interest from disaster response and fire-fighting units, Phelps recalled iRobot's participation post-Fukushima nuclear incident in 2011 when iRobot PackBot UGVs were used to replace human rescue workers.

Initially, the UGVs were utilised for situation awareness, with each vehicle equipped with a video camera to allow the Tokyo Electric Power Company to monitor live images inside the buildings as well as temperature readings.

MEASURING DOSES

More specifically, he described how UGVs could be used to respond to events as well as test affected areas in order to measure radiation dosages exposed to by workers. Additionally, they could be used to conduct filter change-outs and heavy lifting, he continued.

'The nuclear sector is where we've seen a lot of growth and we are starting to see a similar trend in other industry markets that need to deal with hazardous material (HAZMAT) chemicals, with ground robots used to provide that safe stand-off distance. You can drop one into an inspection space instead of suiting up a team of personnel.'

iRobot already has multiple customers in the nuclear industry, including Canada, Japan and the US, with the 110 First Look UGV used for inspection duties in confined spaces; the 510 Packbot used for manipulation and sensor monitoring; and 710 Cobra for reach and lifting of heavier objects.

Over the past year, iRobot has completed a 'revamp' of its HAZMAT offering with the 510 Packbot. Phelps said there has been a lot of interest from the fire-fighting and emergency response services for confined area search capability.

Indeed, it was this revamp that earned iRobot a $9.6 million contract to provide the Canadian DND with 20 510 PackBot UGVs enhanced for CBRN operations.

> *'We've had a lot of interaction with general police usage for suspicious devices and barricaded suspect hostage situations.'*

A total of five sensor systems were integrated into the platform, designed to detect, alert and report chemical warfare agents, industrial chemicals, explosives, radiation and volatile gases. Upgrades also include a 'rear flipper' for increased mobility.

'We see the threat of CBRN driving demand from multiple areas, whether it's the US DoD or homeland security, the Canadian DND or other international agencies and public safety organisations,' Phelps added. 'Unmanned vehicles with CBRN sensors integrated on them can provide safe stand-off distance to identify and potentially render safe these threats.

'Adapting handheld sensors in use by HAZMAT teams and adapting our robots, we are now able to add a mapping capability to collect sensor data, triage a scenario before sending guys downrange into chemical vapours.'

MAKING ASSESSMENTS

Addressing the wider industrial market, Phelps admitted iRobot was still in the process of assessing the sector while making the transition from 'purpose-built' systems to 'multi-use' UGVs.

'We are working with several markets to do that with hazardous waste above and beyond the nuclear industry and we are considering how they would utilise robots as well as the introduction of the uPoint multi-robot controller,' he said.

'There will be requirements going forward to tailor our products for different commercial , but our platforms are ready to do that. We have the infrastructure in place with the multi-robot controller to provide complete solutions and that fits into the integration of third-party sensors/tools.'

uPoint is described as the 'cornerstone' for future growth of iRobot, featuring an Android-based application to allow standardised control of multiple robots within the company's portfolio. The manufacturer clearly sees modular systems as the future of the UGV market.

'We have a very solid product family at the moment and are witnessing a lot of growth in the modification of tailored but existing platforms,' Phelps concluded.

Powered by a single tablet, the system can drive, manipulate, inspect and communicate with platforms as well as record video and construct 3D UGV models for tasking controls.

Another avenue in the civil sector being explored by various UGV manufacturers is in the oil and gas market, where such platforms are being considered for pipeline inspection. Currently, companies like Aerovironment and Insitu are contracted to support land- and maritime-based oil and gas operations in Alaska. These involve small UAS flying across an area of operations to conduct a variety of tasks, ranging from environmental monitoring through to pipeline inspection.

PIPELINE PRODUCTS

However, one area which these airborne systems are unable to monitor is the underside of land-based pipelines. One company supplying an airborne solution to a large but undisclosed oil firm in the Middle-East is Textron Systems. David Phillips, VP of small/medium endurance UAS at the company, explained to *Unmanned Vehicles* that the firm is in discussions with a number of undisclosed UGV providers to address this capability gap.

'I know that speaking with some unmanned ground system providers, that some of the pipelines up in Alaska are looking at that,' he said, describing such 'linear inspection' from the ground.

'Travelling under the pipeline and looking up at possible damage areas is important for these oil companies, looking for leaks and anything that would be environmentally detrimental.

Whatever the future entails for the civil market, industry appears set to increase the number of applications for unmanned ground vehicles. **UV**

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Taking in the sights

Whether on the ground, at sea or in the air, unmanned systems are finding greater utility in the environmental monitoring sphere. **Claire Apthorp** assesses industry's efforts to penetrate this market.

Environmental-related industries are now better at utilising unmanned technology, as organisations increasingly seek innovative and cost-effective ways to collect data and inform research and studies.

A combination of UAS, USVs and UMVs are deploying the technology to monitor weather, animal populations and vegetation, offering more efficient methods than those offered by manned platforms. Crossover commercial sectors, such as oil and gas or agriculture, are also using the platforms to assess the impact and progress of their work on the environment.

IN THE AIR

Best-known for its work with the US military, Textron Systems' Aerosonde UAS has its roots in the environmental monitoring market. In 2005, the platform became the first of its type to be successfully flown into the core of a mature tropical storm system (Hurricane Ophelia) as part of work with the US National Oceanic and Atmospheric Administration (NOAA) and NASA.

It documented areas that were previously impossible or impractical to observe, including collecting near-surface windspeed measurements and high-resolution thermodynamic and kinematic observations within the storm's low-level inner core.

'Being a UAV, Aerosonde is able to fly into the eye of the hurricane and take measurements at altitudes as low as 100m above the surface of the ocean,' David Phillips, VP of small/medium-endurance UAS at Textron Systems Unmanned Systems, told *Unmanned Vehicles*. 'This results in much more accurate measurements than can be obtained with piloted aircraft, which have to fly at much higher elevations.'

The system is also used for monitoring illegal fishing activities, including a project with the government of Palau to supplement the island nation's sole patrol vessel by monitoring the exclusive economic zone and relaying fishing vessel registration information to onshore operation centres for confirmation of permits to work in the zone.

PROOF OF CARE

One area in particular that is picking up pace for UAV applications is offshore oil and gas, where regulatory codes require companies to show their work is not negatively affecting the surrounding environment.

'In 2013, Aerosonde conducted environmental regulatory work in Western Australia, where it was used to ensure that offshore drilling off Perth was not impacting the local sea turtle population,' continued Phillips. 'Using a high-definition payload, Aerosonde was tasked to monitor certain beach areas over a period of several months, taking photographs of turtle tracks and eggs, and by creating a mosaic of the imagery the user was able to show that the drilling was not impacting the turtle population.'

A major growth area for UAS service providers is in agricultural science ('agriscience'), where the use of specialised payloads can provide detailed information for precision farming.

Galileo Group, for example, uses emerging technologies such as hyperspectral imaging and 3D laser scanning to deliver enhanced information and plant metrics over large areas. The former involves the simultaneous collection of several hundred digitised layers of discrete ➤

The Aerosonde UAS supported meteorological research in Antarctica in 2012

TEXTRON SYSTEMS

LIQUID ROBOTICS

Liquid Robotics' Wave Glider SV3 USV provides an alternative to buoys for hurricane and tsunami monitoring applications

spectra of all the objects in a given scene within a given wavelength range.

Hyperspectral imaging possesses the spatial resolution to delineate individual plants and the temporal advantage of tracking changes throughout the growing cycle. The spectral response of vegetative materials can be exploited to build a virtual model of vegetation, allowing key plant traits to be correlated with unique mathematical observables.

'Hyperspectral imaging covers the entire spectrum from 400mm up to 2,500mm – hundreds of bands – building a continuous shape of the reflection of the surface,' explained Thorsten Mewes, hyperspectral imagery scientist at Galileo Group. 'So we are measuring the reflection of the surface with those bands and the shape of the reflections, and using advanced algorithms to detect certain minerals, threatened crops and differentiate different classes of vegetation.'

ON THE MAP

In addition to agriscience, the same technique can be applied to coastal mapping – for aquatic vegetation mapping, coral reef and wetland monitoring, oil spill mapping, as well as oil and gas exploration and mineral mapping. High-resolution mineral, alteration or mineralisation zone maps can be created from spectral information to assess and prioritise exploration mineral targets, identify oil seeps and detect micro-seepage through hydrocarbon-induced surface manifestations for oil exploration.

'In the past, we were using manned helicopters and small fixed-wing planes, but the demand for UAVs is growing,' added Mewes. 'This is because in the agricultural field customers are interested in having data continuously taken over weeks or months during the growing cycle to see how seed production is going, looking for problems in the fields and to conduct variation studies and test new gene types and how they perform.

'To have a helicopter and pilot available for weekly collection is tough and – even for a big agricultural company – the costs are tremendous, so a small UAV with a sensor that can be delivered to the field in a truck to collect the data weekly is a lot more affordable.'

Maritime Robotics is also finding a fledgling market with its UAV offering. The company provides a customised Penguin UAV airframe carrying payloads to suit specific requirements.

It recently conducted geophysical survey work in the north of Norway, where an aeromagnetic mapping payload that charts the magnetism of the Earth was used to provide information on what mineral types were present, and is also moving into the environmental crossover market of oil and gas exploration and production.

Here, the Penguin UAV carries an EO/IR sensor for maritime aerial surveillance, locating, monitoring and responding to oil spills. However there is still work to do to expand this market in the face of developing civil airspace regulations that restrict the use of UAVs.

'Our main product for oil spill surveillance remains our OceanEye tethered aerostat system carrying the basic maritime observation package and AIS receiver,' Vegard Evjen Hovstein, MD of Maritime Robotics, told *UV*. 'This is what we sell the most of and the reason for that is that in every country we sell to, the regulations for the operation of balloon systems are crystal clear, and that is a huge advantage compared to the UAV. Of course, once airspace regulations are resolved, demand for the UAV will follow.'

MARITIME MARKETS

Maritime Robotics also offers a USV solution to the environmental monitoring and geophysical exploration market with its Mariner. Based on the PolarCirkel workboat, it can carry a range of surface and sub-surface payloads, including EO/IR camera, radar, oceanographic instruments, hydro-acoustic positioning systems, echo sounders and sonar systems. The platform has an endurance of 50-60 hours at typical survey speed.

'For the environmental monitoring market, we are equipping the USV with a MetOcean sensor package, which includes conductivity, temperature and density measurement, an acoustic Doppler current profiler for measuring currents at different water depths, a wave height measurement sensor and a general meteorological sensor,' said Hovstein.

'The true commercial market is still in its very early days, but we are seeing an early market among government research organisations – it's quite a conservative market, so we try to emphasise that the Mariner can make operations more efficient by adding value to your existing fleet, rather than replacing it.'

LONG LASTING

One of the most significant performance gains delivered by unmanned technology in the environmental monitoring field is persistence. In order to fully maximise the endurance of its solution, Liquid Robotics has tapped into energy harvesting technology to enable its Wave Glider SV3 to stay at sea 24/7 via a hybrid power and propulsion system.

> *'A small UAV with a sensor that can be delivered on a truck is a lot more affordable.'*

The USV's propulsion – typically the biggest draw on power for any autonomous vessel – is generated by water action, with the movement of the waves directly and mechanically translated into propulsion power. Other onboard systems, including computers, GPS, SATCOM and scientific sensors, draw comparatively little power and are instead sustained with solar panels. An auxiliary vectored thruster is used for extra speed to address difficult ocean conditions, or to accommodate changes in mission operations.

'In theory, Wave Glider SV3 can stay at sea indefinitely, but in practice we recommend a one-year maintenance cycle where it is brought back to shore and serviced,' Francois Leroy, senior VP of science and commercial markets at Liquid Robotics, told *UV*. 'That means you have one year where you don't have to recharge, refuel or get to the platform to intervene – the longest we have left a system at sea for testing purposes was two years.'

With over 100 SV3 systems delivered to customers, it has broad application in environmental/scientific markets, with payloads (45kg maximum) capable of collecting and relaying large volumes of data for environmental monitoring, global weather, tsunami early warning and CO_2 monitoring; as well as commercial applications in fisheries

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stock assessment and marine mammal monitoring, among others.

The most widely utilised baseline payload is the MetOcean package: meteorological and oceanographic sensors for capturing data on weather patterns and ocean dynamics; and an acoustic payload for listening to marine mammals or measuring ambient noise – an increasing requirement in the European Community as users seek to understand the baseline ambient noise of the ocean and how it is affected by industry projects, such as offshore wind farms.

IMPROVING DATA COLLECTION

Wave Glider is proving itself an effective and reliable alternative to buoys, which face a number of issues that can complicate or reduce their effectiveness for data collection, such as sensors being easily washed off, or the buoy losing its moorings in rough weather.

'NOAA had several cases where very strong hurricanes came through the region and the buoys they had in operation would fairly systematically go offline as the storm passed by, whereas Wave Glider has been capable of sustaining those storms nicely,' added Leroy.

Similarly, the USV can provide early warning for tsunamis in a much more efficient manner than warning buoys, which are few and far between, often offline, and costly to install and maintain. Wave Glider lowers a sensor to the sea floor to measure changes in the pressure of the water column, which can be analysed and recognised as a tsunami. When this occurs, it will broadcast a message to the platform, which relays the data through SATCOM back to shore, acting as a gateway for the alarm.

Liquid Robotics believes that there are many more ways that Wave Glider technology can be utilised, with research now looking at networks of platforms and how large fleets can be deployed and collaborate together. However, the impact the technology is having on the way environmental studies are conducted is already apparent.

'Before this technology, there was very little sampling carried out, with studies relying a lot on modelling, where a few samples are taken and a big picture is extrapolated from that,' Leroy continued. 'Now we are shifting towards a situation where we are able to gather much broader sample sets of real data, and then improve the models and the big picture with real-time data rather than statistics, so we really are getting the real picture instead of a model picture.'

UNDERWATER AWARENESS

The ability to monitor underwater areas as part of environmental research programmes is also growing.

Kongsberg Maritime AUVs have been operating in the commercial and scientific sectors since the early 1990s, including for environmental work. The HUGIN AUV conducted the first commercial survey of the Åsgard Gas Transport Pipeline route in 1997, and since then has gone on to conduct pre-engineering surveys, environmental monitoring research for the Institute of Marine Research to map coral reefs, fishery research and other offshore oil and gas survey work for a range of customers.

'AUVs provide a mobile platform for conducting baseline studies of an area before further exploration is carried out, and they can cover a large area in quite a short time,' Geir Espen Schmidt, VP of AUVs at Kongsberg Maritime – Subsea, told *UV*. 'Also, oil companies need to carry out regular inspections of their underwater pipelines, assess the structures to check for damage and detect leaks.'

The company sees demand for environmental monitoring applications growing, with one of its newest systems – Seaglider – developed for continuous, long-term measurement of oceanographic parameters and environmental properties. The system uses small changes in buoyancy and wings to achieve forward motion, with pitch and roll controlled using adjustable ballast.

The platform is available in two versions: general oceanography, and with increased payload volume for more demanding sensor configurations. The standard fit includes a conductivity, temperature and depth sensor, dissolved oxygen sensors and optical devices. Its applications include physical, chemical or biological oceanography, storm monitoring and active and passive acoustic monitoring of biologics.

'The benefit of Seaglider is that you can have it on the sea floor for up to nine months – depending on the sensor package – to continuously monitor an area,' Schmidt said.

This concept of AUVs remaining submerged for long periods is something Schmidt believes will expand in future, with the platforms becoming a combination static and mobile system that will be a subsea resident, docked to the sea floor and charged and programmed to perform monitoring or inspection as required. UV

MARITIME ROBOTICS

At typical survey speed, the Mariner USV has an endurance of over 50 hours

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Making no impact

Collision avoidance systems are relatively immature and likely to face certification and integration issues for some time, according to some industry voices. **Tony Skinner** looks at where the technology currently is.

A key official from the US Federal Aviation Administration (FAA) caused a stir when he presented his outlook on future UAV integration to the Commercial UAV Show in London in October.

In the face of increasing industry frustration at the lack of regulatory reform needed to allow commercial UAV operations, James Williams, manager of the FAA's UAS Integration Office, argued that the enabling sense and avoid (SAA) technology was simply not yet mature enough.

Defending the seemingly slow pace of reform, he said while the US military had been developing SAA technology for many years, even they were some way off settling on one enabling solution or even establishing a certification process for the equipment.

'I do not believe the technology is there yet today,' Williams argued. 'The US military has been working for a very long time to try to come up with a certifiable detect and avoid system and they are just now reaching the testing stage, where they are going to test it on an aircraft in restricted areas of airspace.

'We are working in parallel with them to develop a standard as the technology matures, so that when the technology is there, there will be a standard by which it can be certified. And at this point… the military don't think they will be ready to certify their aircraft until 2018. So I would argue that the technology really isn't there – it hasn't proven to exist and be reliable for airborne detect and avoid systems.'

UAS ROADMAP

According to the FAA's UAS Roadmap released in 2013, SAA capability must provide for self-separation and ultimately collision avoidance protection between UAS and other aircraft analogous to the 'see and avoid' operation of manned aircraft, at a level that meets an 'acceptable level of safety'.

'SAA technology development is immature,' the document states. 'In manned flight, see and avoid, radar, visual sighting, separation standards, proven technologies and procedures and well-defined pilot behaviours combine to ensure safe operation. Unmanned flight will require new or revised operational rules to regulate the use of SAA systems as an alternate method to comply with see and avoid operational rules currently required of manned aircraft.'

In the UK, while the skies are beginning to open to some commercial UAV operations, the Civil Aviation Authority (CAA) has adopted a three-stage approach that does not envisage 'seamless integration' until at least 2028 when the full regulatory framework is expected to be in place.

The CAA sees 'proportionality' as being the correct approach and currently enforces regulations on a sliding scale across Categories A, B, and C, depending on the perceived level of risk.

Gerry Corbett, UAS programme lead at the authority's Safety and Airspace Regulation Group, noted that no operator had yet approached the CAA with a mature SAA system. 'I've seen a few embryonic systems and told them to get it up, but they said they haven't got the money to go ahead,' he said. 'The push doesn't seem to be there at the moment – I wish it was.'

The claims that the technology is immature were rubbished by industry advocates at the conference – as well as several company representatives that did not wish to go on the

TEXTRON SYSTEMS

Textron Systems recently announced it had been authorised to start Aerosonde SUAS operations with the Mid-Atlantic Aviation Partnership

The army is installing GBSAA radar systems at five installations around the US to allow the MQ-1C Gray Eagle to fly safely in domestic airspace without a chase plane or ground observer

US ARMY

record – who argued that pegging the problem to the Pentagon's own development of SAA technology was a digression, as until recently the military has largely been operating UAVs in the uncontested airspaces of Afghanistan and Iraq.

DISPLACED COMMENTS

Meanwhile, Small UAV Coalition executive director Michael Drobac told *Unmanned Vehicles* it was 'discouraging' to hear an FAA official make such comments at a commercial UAV exhibition.

'We know from the companies that we are working with and others that they are actively testing sense and avoid technologies and are already using it in many countries. So the concept that the response is "we have talked with the military and it is not happening" and you are at a commercial UAV conference, seems to me to be a little bit displaced, he argued (for more, see p36).

Drobac said the comments that the military was unable to prove that sense and avoid works showed that the FAA was 'talking to the wrong people', while the Small UAV Coalition was already engaging with companies that were innovating and developing working SAA technology.

'This is when we get frustrated – you have a high-ranking official at the FAA saying UAVs are unsafe,' he stated. 'Then you think about countries that are been using them for decades and you think if they're not safe, how was it they have been used two decades in Japan, how was it they have been used effectively in a couple of handfuls of countries for operations already?

'And the answer is that it is easier to say that our airspace is more complex, it is easier to say that we have to address these issues in a methodical drawn-out process. But easy is not the way we need to go with UAV technology.'

INTEGRATION ISSUES

Following a UAS group conference at the Royal Aeronautical Society in London in June, Tony Duthie of the society's UAS Specialist Group, outlined the various aspects of the issue. He agreed that the lack of agreed sets of user requirements for small to large, fixed- and rotary-wing UAS operating in the various classes of airspace was hindering the successful integration of unmanned aircraft into civil airspace.

'Although regulatory frameworks have been established in some countries for small RPAS and trials of larger RPAS, the overarching regulations and standards are still being developed by national and international bodies,' he explained.

Nevertheless, the Pentagon is currently running a myriad of efforts to further develop its ability to operate UAVs in US airspace and is engaging with industry to develop the enabling technologies.

For example, the UAS Executive Committee (EXCOM) – a partnership between the US DoD, the FAA, NASA and the Department of Homeland Security – has appealed for information on how to reduce the SWaP and cost of SAA systems for both fixed- and rotary-wing UAS. EXCOM held an industry open day on 28-29 October to outline the activities of its Science and Research Panel (SARP), which comprises experts from organisations performing SAA research.

The SARP is also asking industry for information on processes to lower certification costs; how detection technologies from other industries might be adapted to UAS SAA; and surveillance technologies – ground-based or airborne – that may accomplish SAA for beyond-line-of-sight small UAS operations at low altitudes.

The DoD has split its other SAA developmental activities into distinct efforts: the Ground Based Sense and Avoid (GBSAA) led by the US Army (although both the USAF and USMC have fielded incremental solutions for immediate needs); and the Airborne Sense and Avoid (ABSAA) solution overseen by the USAF.

According to GBSAA deputy product director Mary Ottman, the army flew the first prototype GBSAA system at El Mirage, California, in 2011 and plans to conduct operations with the first compliant GBSAA system in 2015.

The army is installing GBSAA radar systems, developed by SRCTec, at five installations around the US to allow the MQ-1C Gray Eagle to fly safely in domestic airspace without a chase plane or ground observer.

The LSTAR radar systems are remotely operated and their data is correlated with other information to provide a surveillance network sufficient to meet FAA regulations, according to SRCTec.

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WIKIMEDIA COMMONS

The slow pace of regulatory reform in the US is preventing small UAVs from being employed for commercial uses – the FAA has created six test sites to speed things up

NEAR-TERM CAPABILITY

In addition, the US Navy is developing a near-term ABSAA capability to support MQ-4C Triton operations. In November, Naval Air Systems Command (NAVAIR) asked industry for information on SAA radar capabilities that would allow the Triton to operate in US national airspace system (NAS).

'The SAA radar must be capable of operating in a wide range of natural, induced and air traffic environments expected over the MQ-4C life cycle, during all phase of flight,' NAVAIR stated in its RfI. 'Due to performance impacts associated with ground clutter, it is anticipated that an onboard air-to-air radar may require supplemental capability from ground-based radars when operating in the terminal environment, below certain altitudes.'

Meanwhile, the USAF has been carrying out market research to look at the possibility of transitioning current SAA technologies into a Common-ABSAA system, which will allow it to obtain approval from the FAA to perform integrated flight within the NAS without applying for a certificate of authorisation (COA) in advance.

'Given the results of R&D efforts over the past few years, it is now possible to equip RPAS with technology that will address some of the major requirements currently driving the FAA COA process,' according to the USAF.

The service has launched an initial technology development effort to mature the integration effort to a preliminary design configuration and at least 21 companies – from the major defence primes to small systems houses – have responded to the initial RfI.

INDUSTRIAL EFFORTS

Military activity aside, industry is also racing to mature its SAA technologies, spurred on in part by the creation of six authorised test sites set up by the FAA as part of its effort to integrate unmanned aircraft into the NAS.

Most recently, on 8 December Textron Systems Unmanned Systems announced it had been authorised to start Aerosonde SUAS operations with the Mid-Atlantic Aviation Partnership (MAAP), one of the six test sites.

With an emphasis on enabling UAS integration into the NAS, the flights will 'contribute to proving the agricultural and environmental applications of unmanned systems, while developing safety, operations and training protocols between MAAP, the local airspace authority and Textron Systems', according to the company.

General Atomics Aeronautical Systems (GA-ASI) conducted a series of flight tests with a company-owned Predator B to prove its SAA architecture and self-separation functionality.

The tests integrated BAE Systems' AD/DPX-7 IFF transponder with ADS-B IN, GA-ASI's air-to-air radar, called Due Regard Radar (DRR), and Honeywell's Traffic Alert Collision Avoidance System (TCAS) TPA-100 to detect and track cooperative and non-cooperative aircraft.

'Sensor data collected by these systems during the flight test will be used by the FAA and industry participants to develop and further refine their algorithms, which will in turn lead to a proof-of-concept SAA system including collision avoidance,' the company said in a December 2013 release.

TESTING PROTOTYPES

Elsewhere, Sierra Nevada has been working with the Air Force Research Laboratory under its Multi Sensor Detect Sense and Avoid (MSDSA) programme to test its prototype radar sensor, while the University of North Dakota's UAS laboratory has a long-running project to employ ADS-B as an SAA system for UAVs.

Despite such progress, the glacier-like pace of regulatory change in the US is causing concern in industry circles that North America may be overtaken by other regions in the development of the technology.

In Australia, the Queensland University of Technology has been working with Boeing Australia and Insitu Pacific to develop an onboard system enabling a UAS to detect another aircraft 'using vision while in flight'.

In what it described as 'a world-first breakthrough', the system provided real-time warnings back to the GCS, resulting in a successful manual collision avoidance manoeuvre.

A similar capability was on display from 26 October to 7 November in France, where Sagem demonstrated a complete anti-collision function during some 20 test flights of its Patroller UAV.

The 'see and avoid' system integrated in the Patroller's control system combined traffic detection sensors, including an EO/IR sensor, and an automatic risk collision estimation and avoidance flight path generation module.

'During the flight tests, this system was successfully operated using different conflict scenarios with a dummy aircraft provided by ENAC [France's national civil aviation school], thus enabling Patroller to detect the risk of a collision and avoid it, without requiring an operator,' a company statement explained.

HEADING OFFSHORE

For the Small UAV Coalition, such developments raise the spectre that US companies may choose to go offshore to further develop the required SAA technologies without the restrictions currently imposed in the US.

'When we think that the US is losing a position, then we will be thrilled to work with the UK to help groups there, where we are seeing some incredible movement and great thought leadership,' Drobac told *UV*. 'That might be where we will see most of the US companies soon – UK, Australia – they may go on to other markets and the reality is that is where you may see the technology take off.

'We come back to a simple thing, which is that technology always wins. It doesn't matter how many barriers we put up, how much resistance there is, this will prevail, this technology will be ubiquitous. We want people to come aboard and to support what is happening because we think it can be the next incredible technology that will captivate consumers and change the economy.' UV

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Home schooling

TEXTRON SYSTEMS

Textron Systems has created a training package to bring Shadow V1 operators up to date with V2's capabilities when it arrives in January

UAS training procedures are changing to reflect a somewhat uncertain operating environment post-Afghanistan. **Scott R Gourley** discusses the US Army's new approach with representatives from both the service and industry.

The drawdown in Afghanistan has helped usher in a new training environment for UAS. Forces are moving out of tactical operating environments and back to steady-state training locations. In the case of the US Army, the transition to home stations is giving UAS service planners and industry a mix of new opportunities and challenges.

'In the past 15 years, the [US] Army was very focused on building capacity of UAS,' explained Col Thomas von Eschenbach, capability manager for UAS at US Army Training and Doctrine Command (TRADOC).

'We procured a lot of systems and did a lot of rapid fielding. Now we're looking at how we take the capacity we have and increase the capability through better training and integration with other formations to make it to where home station training is just like we did it in combat.'

AVOIDING REPETITION

Von Eschenbach described the overall UAS situation in-theatre 'like pick up', noting that the UAS systems were 'there and fielded', so the army may not have carried out much UAS training at home stations.

'Over time it became almost repetitive, where we dealt with the same scenarios in Iraq and Afghanistan, with basically a fixed base,' he continued. 'But now, as we look to the future, how do we train for an environment that's very hard to predict?'

In his role as 'the integrator of all UAS parts and pieces across doctrinal, organisational and training issues' as well as coordinating with the army's programme management offices on some material issues, von Eschenbach is helping craft out what the future training environment might be. He believes that this depends on the answer to the simple question: why is UAS a critical component of the future?

TECHNOLOGICAL JUMPS

'UAS is a capability that extends the commander's ability to do things,' he responded. 'It increases his situational understanding of the battlefield by allowing an unmanned system to get out a little bit farther.

'The sensors and technology we [possess] have really come leaps and bounds in the past 15 years, allowing the commander to make decisions at the right place and the right time regarding where to put his manned systems.'

Clearly, his thoughts are well in line with the army's strategy of UAS being 'a critical piece of the [service's] unified land operations doctrinal construct'.

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VIA AUTHOR

Future baseline training will focus more on how UAS operators can support soldiers and commanders on the ground with precise intel

In his discussions across the military, von Eschenbach builds on this with a second question: how many soldiers are in the UAS formations?

'When they understand that a Shadow platoon has 27 soldiers in it and a Gray Eagle company has 128, the fact that the system is "unmanned" isn't part of the discussion anymore,' he replied. 'The discussion shifts to: "What do these soldiers do as the centrepiece of these formations?"'

For systems like Shadow and Gray Eagle, the baseline UAS training for many of these soldiers is provided at the 2nd Battalion,13th Aviation Regiment, based at Fort Huachuca, Arizona. It is the world's largest UAS training centre and the 600-person battalion essentially provides 'flight school west' for US Army unmanned aviation.

'It's important to realise that our guys out at Fort Huachuca are providing the foundational training environment for our "15 Whiskey" operators, our "15 Echo" maintainers and the "150 Uniform" warrant officers,' said Col Shawn Prickett, commander of the 1st Aviation Brigade, which includes 2nd Battalion, 13th Aviation Regiment.

'That foundational training is in line with the TRADOC mission to train, educate and provide those soldiers to the operational force at that baseline level. So, similar to what we do here at [the helicopter] Flight School at Fort Rucker, we are doing the same things at Fort Huachuca.'

TODAY'S TRAINING

Asked about changes in that baseline UAS instruction over the past few years, Prickett said that today's training is 'using the Army Learning Model 2015 teaching techniques,' which feature increased levels of adaptive and situational training as well as 'state-of-the-art simulations'.

In terms of specific skill sets for future development, Prickett identified UAS gunnery as one area to receive increased attention.

'From a variety of sources in the field and our [experience] in Operation *Enduring Freedom*, we realised that gunnery was one of the skills where some of our operators were lacking,' he said. 'So we have really improved the gunnery programme at the school.'

'We're also taking some great strides with regards to technology, so as technology continues to improve, our training out there has to improve.'

Prickett emphasised that the new focus of all baseline training 'is really air-ground operations and supporting the soldiers and commanders on the ground with precise reconnaissance – enhancing the capability of the commander'.

E-LEARNING

In addition to army baseline training at Fort Huachuca, there are other industry programmes, ranging from primary operator training for small UAS to new equipment training for enhancements to the larger platforms.

In the case of small UAS, for example, Bart Decker, flight standards manager at AeroVironment, describes the training environment he first entered in 2004, noting that the presence of Raven A, coupled with operations in both Iraq and Afghanistan, translated to significant demand for training.

'So we started a training team of six of us in December 2004 and by June 2005 we had grown to 30 guys,' he said. 'At that time, we were "the trainers for big army". We had soldiers from privates to non-commissioned officers without any background in UAVs and they were getting trained.'

Although that contract subsequently went to another entity, Decker said that AeroVironment has continued to focus on small UAS training requirements, with an eye towards simplification and client cost reduction.

He noted that the original class structure was a ten-day course, with the first five spent in morning classroom sessions reinforced by afternoon flights. The last four – the fifth was a spare for bad weather – were devoted to flight operations.

'That was the old training programme, which we developed and wrote,' he continued. 'Then the army bought it and used that curriculum.'

Decker said that the primary problem with the programme was that it took students out of their primary career field for these ten days. Another complication was the availability of funding if soldiers had to be sent to the training on temporary duty status.'

'At the beginning we were running 24-man classes,' he said. 'Then we brought it down to a class size of 16, with four students to one instructor.

'But time and money was still a constraint, so right now we are about to launch a new e-learning, computer-based training capability. For the customer, that can save them time and money and it also gives them some options.'

He continued: 'For example, because you will be able to run this on pretty much any digital platform, customers will have the option of starting the training at their home station, getting through the gates to a point where they can't go any further. Then they would go to a location to do the hands-on flying. But they would only be at that location for a minimal amount of time as compared to the old nine to ten-day training course.'

AeroVironment has already subcontracted the software to one company and the e-learning product should be publicly released early in 2015.

'Right now we're not tied to any training contract with the army,' Decker explained. 'But this is a new capability. We think it's a great approach and time to turn the corner by trying something new that can help the customer out.'

DELTA TRAINING

Along with industry participation in operator training for small UAS, other industry teams provide new equipment training when UAS systems are upgraded or enhanced.

According to Alan Stull, VP of unmanned systems services at Textron Systems Support Solutions, his company currently provides maintenance and operations training for Shadow, new equipment training for the soon-to-be-fielded Shadow Version 2 and 'some support' for the army's UAS training centre at Fort Huachuca.

'The upcoming thing we have involves fielding our Version 2 of the Shadow UAS,' he said. 'That fielding will start in January 2015 and we will be doing the new equipment training as those systems field through 2019.'

Stull describes the new equipment training programme as 'an eight-week course where we go to the unit's location and train them on the [Shadow] Version 2 as the army fields it to them.

'It's really what I call "Delta Training". All of these soldiers are already Shadow operators, so really we are just teaching them the differences between Version 1 and Version 2 of the system.'

In addition to training support to the Shadow UAS, he said that the Textron teams provide new equipment training for the US Army's Gray Eagle UAS as it is fielded.

'We do it in support of General Atomics [Aeronautical Systems] as the prime for that,' continued Stull. 'But we have all of the operators that do the training. It is the same kind of thing – from classroom instruction, into simulators and then out to the flight line where they actually fly. Then we also train our own operators as well.

'On Gray Eagle, as part of our support, we actually embed instructor/operators in those new units. It's not a permanent thing. Typically, as a unit fields, if they are stateside we have one instructor/operator with that unit and then when they deploy we have two instructor/operators who stay with them, to help them maintain their proficiency until the army builds that core competency in Gray Eagle operators.'

VIA AUTHOR

Trainees watch on at one of the US Army's OSGCS, which has been in service since 2001, logging more than 50,000 hours of operation

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Operating UAS requires a mix of civil and military personnel, and in the future would-be UAS operators will be able to 'e-learn' from their home station before hands-on flying elsewhere

Although the contractor instructor/operators have yet to be removed from the early Gray Eagle units, Stull said the longer term intention is to go to a 'regional concept', where instructor/operators 'will be available regionally to support those units.'

'From the training side, we have a very tailorable training package for both those platforms,' he summarised. 'On Shadow, we also write all technical manuals. On Gray Eagle, we only write the technical manuals for our Universal Ground Control Station [UGCS], which Textron Systems produces.'

Stull added that the UGCS is being implemented as part of the V2 Shadow fielding and will be part of the new equipment training. However, while Gray Eagle will eventually receive the UGCS, the systems are currently using the One System Ground Control Station.

'So as we go through this Gray Eagle fielding, we will go back to those units when UGCS is ready to field to Gray Eagle and give them additional training on the UGCS product,' he said.

MANNED-UNMANNED TEAMS

Looking towards the future of the US Army's UAS training, von Eschenbach acknowledged that it will be 'very difficult to have ten years of experience and then peel away from that and not use it as our example to fight and do everything.'

He said: 'I'm not sure any military does well at predicting the next fight, so I think we all have to look at it and ask what's required. What do we need and do we have the resources to do it?

'There are a lot of requirements out there. Could we use UAS to provide some kind of EW capability? Do we use them to increase our signals intelligence? Is a cargo UAS something that the army wants to provide in the future? Do we increase the types of armament on there? Those are all questions that the army is studying and looking at in terms of what roles and missions the UAS provides.'

KNOWLEDGE IS POWER

Regardless of any future expansion in roles and missions, von Eschenbach stresses that the key to future training 'is not whether the UAS formations know how to do that, but rather how ground manoeuvre commanders and aviation leaders know and understand how to integrate UAS into those [training] scenarios.'

Much of that integration will stem from new manned–unmanned teaming that can be created in a simulation environment through linkages between systems like the Universal Mission Simulator and manned elements of the Aviation Combined Arms Tactical Trainer (AVCATT).

> *'We're working on connecting our UAS simulation systems with our manned ones so they can practise operations together.'*

'We're working on connecting our UAS simulation systems with our manned systems,' von Eschenbach says. 'Then in a simulations mode you can get your manned formations and unmanned formations together to practise the things they could only do maybe in live before.'

LINKING UP

According to Kirk Thomas, lead systems engineer and acting product director for AVCATT within Program Executive Office for Simulation Training and Instrumentation, the army currently does have the capability to link AVCATT with the UAS Universal Mission Simulator.

'But the solution we have there has some artificial constraints,' he explained, pointing to features like the use of a tablet to serve as a multi-function display (MFD).

He noted that near-term integration efforts would deliver the video onto the actual manned AVCATT element MFD panel with expanded fidelity.

However, von Eschenbach sees a future that goes well beyond better simulation linkages between manned and unmanned platforms.

'The future of UAS training is not only training the UAS operator, but also those manned formations on how to best employ their UAS,' he concluded. 'It's like the reason that Army Aviation is what it is. Army Aviation is not an airpower organisation, rather it is a piece of a ground component and part of a ground commander's ability to do something on the ground – Army UAS is the same thing.' **UV**

Control groups

NORTHROP GRUMMAN

In June, CPI announced that it had been chosen to supply dual-axis Ku-band data link equipment for the NATO Global Hawk AGS

Two data link systems have recently launched that are promising new capabilities to a technologically slow-moving marketplace. **Peter Donaldson** provides a detailed overview of the latest offerings.

In an industry used to a fast pace of development, data links are relatively slow to evolve, although two innovative systems have recently made headlines within weeks of each other.

On 15 September, Kratos subsidiary Micro Systems Inc (MSI) announced the successful demonstration of its Universal C2 system, also known as the Multi-Service Data Link (MSDL), which can run a number of software data links to control multiple vehicles simultaneously.

Meanwhile, on 1 October Patria announced the launch of its Compact Airborne Networking Data Link (CANDL). Designed with small UAVs in mind, particularly VTOL aircraft, it handles C2 and payload data together – functions that are normally separate.

Jani Reiman, Patria's marketing and sales director, described CANDL as the 'optimal' single data link solution for UAVs with maximum take-off weights between 100 and 1,250kg. In larger platforms, typically carrying a SATCOM link, it provides a solution for networking in a multi-data link architecture, he said.

Although CANDL is fresh from its launch at MILCOM in October, Patria is ready to deliver, according to Simo Mäkipaja, the company's senior VP of business development, who added that it will be flown later this year.

'VTOL platforms are becoming increasingly popular and because of their size are moving towards a single data link architecture as opposed to the traditional division into separate ones for C2 and payload data,' he explained, adding that the growing role of UAVs in network-centric operations is driving data link requirements. 'Point-to-point links are no longer enough and networking characteristics are becoming more and more important.'

BARRIERS TO INNOVATION

Mick Owens, MSI's lead design engineer for the MSDL, commented that new unmanned vehicle (UV) data link systems are rare even though newly available technologies could significantly enlarge the platforms' performance envelopes, citing resistance to change that stems from logistical, technical and regulatory hurdles that must be surmounted before even minor changes or upgrades can be made.

'Legacy data link systems often work their way into new UV systems since [platform]

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developers tend to reuse them to overcome the perceived risks of new systems and because of the high costs of new development efforts,' he said. 'These decisions inadvertently extend the lifespans of legacy systems for many years, sometimes even decades.'

Data link customers, he told *UV*, often want systems that are smaller, cheaper, more modular, adaptable and non-proprietary, making life difficult for equipment designers faced with accepting the risks of developing original systems with no protection for their investment. In recent years, this has driven new customers to use COTS radio systems that operate in open frequency bands and offer limited power and range.

'These COTS radio systems are rarely optimised for UV applications, but they are usually low enough in cost and easy enough to implement to be good enough,' continued Owens. 'In the meantime, custom UV data links have become more expensive and more difficult to develop since no company can afford to keep a staff of experienced radio designers on board in case a new data link opportunity presents itself.'

GROWTH THROUGH SOFTWARE

Given the chance to build a state-of-the-art UAV data link, suppliers combine several technologies, which must all work together within very tight SWaP constraints, according to Patria product group manager Jouni Wirtavuori.

USAF

Although MSDL has been developed to control target vehicles, applications can even extend to the unmanned QF-4 droned jet

'The software-defined radio [SDR] approach enables easy tailoring to customer-specific operational needs and leaves options for future growth,' he said. 'Another key technology is reliable and robust IP-based networking, which enables UAVs to communicate and operate jointly with other platforms. Both automatic and user-controlled adaptation to different channel conditions and information exchange requirements ensure optimal performance in various scenarios.'

Although MSDL has been developed for target vehicles, applications can vary from ocean-going ships, pickup trucks, military cargo vehicles, subscale aerial targets with fighter-like capabilities to even full-scale droned fighter jets such as the QF-4 and the new QF-16. Owens told *UV* that MSDL can support line-of-sight operations for the platforms beyond 320km, extending to more than 560km with an over-the-horizon relay system.

'It uses a spectrally efficient modulation technique that is similar to GSM and operates in a military-only UHF frequency band,' he explained. 'The system can operate on any one of over 500 channels within the UHF band, and it has the ability to change channels at any time during an active mission.'

Offering high data rates, MSDL also features multiple external serial bus interfaces to accommodate a range of different vehicles. The company recently demonstrated the system's ability to provide radio location services in GPS-denied environments.

MSDL evolved in response to the need to replace a COTS data link developed in the 1990s for aerial target systems. In a collaborative effort, MSI worked on the design implementations to meet the requirements set out by the US Navy. 'The system is now regarded as one of the most successful joint development efforts between the military and industry in many years,' claimed Owens.

MSDL is designed to replace any of the legacy UV data links currently in service. 'Many discussions have been held with the USAF, US Army and US Navy and each branch has developed its own roadmap for migrating to the new data link,' he added.

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MULTI-VEHICLE CONTROL

The idea at the heart of the MSDL is to provide a flexible system for greater commonality and the ability to control multiple vehicles at the same time. It can run eight vehicles on a single channel and can operate on three channels, for a combined total of 24 surface or aerial vehicles. Owens said that it can control any combination of surface and aerial vehicles during any given mission.

To keep workload within manageable limits, the control system allocates one vehicle to each operator, providing the necessary tracking, telemetry and situational awareness. Each MSDL system also has a master control console that continuously provides status information on the complete data link package, allowing the operator to take action if a subsystem develops a fault or suffers an interruption of service. The master control operator can switch to a back-up frequency or system if a problem occurs, leaving the vehicle operators to focus on their charges.

All the data link software runs on MSDL and MSI developed the user and equipment interfaces, software, firmware and radio hardware to meet military requirements, Owens explained. All the company's data link systems are software-intensive and deliberately so.

'This has allowed us to abstract the software from the hardware, thus giving our customers many hardware configuration options,' he said. 'This relieves them from the logistics and obsolescence issues that have plagued data link systems in the past.'

MSDL runs on Windows 7, which the US Army and US Navy specified for its compliance with information assurance standards, and controls specialised RF hardware designed to military requirements. The complete design of the system, including the hardware, software and firmware, is owned and controlled by the latter service.

FORMAL QUALIFICATION

With the first two design and development stages complete, the focus is now on the final stages of formal qualification testing for naval operations. MSDL has been through MIL-STD-810G environmental tests and is now ready to start electromagnetic interference testing to MIL-STD-461F, after which formal software qualification assessments will begin. Frequency allocation approval is in process and the navy expects the system to become fully operational in 2016.

More capabilities and features that will allow MSDL to accommodate future C2 systems are soon to be implemented in the software and firmware, and the company is under contract to develop and demonstrate them to the navy within the next two years.

'Other future developments include investigations into reducing transponder size and weight to support future applications for small, low-cost data link operations,' said Owen.

Frequency allocation is a major preoccupation for everybody in the radio communications business, perhaps even more so than finding the bandwidth to carry sensor data, explained Mäkipaja.

'It's not so much a question of maximising the bandwidth,' he said. 'While the sensor systems do produce immense amounts of data, the packing and compression techniques also [continually] evolve. Moreover, it will become more and more challenging to find available frequencies for the wideband links. So it will – or already has – become a game of optimising between desired bandwidth and available frequencies.'

PATRIA

Patria's CANDL can achieve data rates of up to 8Mbps in a single SDR-based airborne terminal

Patria's CANDL carries C2 dynamic IP networking, full-motion video and digital voice, achieving data rates of up to 8Mbps in a single SDR-based airborne terminal. It covers the NATO C-band and the civil UAS C2 frequency band defined by the 2013 World Radio Communication conference, supporting long-range networking in the air-to-air and air-to-ground regimes and offering relay functions for beyond-line-of-sight communications. ➤

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LIMITED BANDWIDTH

A spokesperson for Communications & Power Industries' (CPI) Malibu division, pointed out that data links operating in the C-band and below are bandwidth-limited and present challenges in transmitting full HD video and synthetic aperture radar data simultaneously. 'There is no such limitation [for the] Ku-band data links primarily used by the US DoD,' explained the spokesperson.

On 23 June, CPI Malibu announced that it had been chosen to supply dual-axis Ku-band data link equipment for NATO's Alliance Ground Surveillance (AGS) variant of the Northrop Grumman Global Hawk.

The high-gain AT-23 antennas involved, which can operate in the low temperatures encountered at the UAV's 65,000ft maximum operating altitude, use slotted waveguide array technology, the company confirmed. 'We believe that the unique auto-tracking capability featured in CPI Malibu division's data links is state-of-the-art.'

Reliability, safety and security were high on the list of priorities when developing CANDL, Wirtavuori explained to *UV*. Patria took this approach in order to maintain connectivity even in the most challenging environments with high interference – intentional or otherwise. The Adaptive Networking Waveform (ANW) is at the heart of it, with its ability to adapt to channel conditions and information exchange needs using 'optimal' security features.

'Adaptive spread spectrum signal management is one technique, with a broad RF band [within which] to select the operational frequency band,' he said. 'In CANDL, the RF band and frequency-hopping characteristics, for example, are customer-configurable and can be changed on the fly. ANW also uses direct sequence spreading, error correction and multiple robust synchronisation methods. Furthermore, support for two antennas with diversity selection provides additional reliability and security.'

CANDL is also logically divided into a secure channel and a wideband channel and the 8Mbps data rate can be allocated as needed on a per-mission basis, depending on the customer's configuration. Although ANW provides key security and reliability features within CANDL, hardware design has an important role.

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MSI

MSDL, which operates in the UHF band and can change channels during active missions, evolved in response to the need to replace a COTS data link developed in the 1990s for aerial targets

'High-performance RF and baseband signal chains with low spurious [signal] levels, good selectivity, high dynamic range and low noise are essential for the anti-jamming capabilities, for example, of the whole system,' said Reiman.

TAKING CONTROL

Meanwhile, Owens emphasised that most of MSI's military customers are very aware of the threat of attacks on their data links. Such threats do not normally involve state secrets, but rather aim to destroy the UAV or take control of it.

Most incidents would be limited to simple jamming techniques because of the difficulties involved in deciphering and controlling the sophisticated modulations and bit coding patterns that the military uses, he explained.

'This means that any malicious military attack could be easily overcome by having the UV navigate to a pre-programmed recovery location if the data link is lost. MSI is not aware of any actual data link attack, but the military has expressed concerns and even developed preliminary concepts for defeating such attempts.'

COTS data links, however, are potentially more susceptible to attack, since anyone with a web account and a valid credit card can buy a sufficiently powerful radio transmitter, he cautioned.

'This gives would-be attackers an easy way to listen in on the communications between a UV and its control system and quickly learn how to hijack the system. Once the hijacker gets detailed knowledge of the bit patterns that are used by the data link, he can easily take control. In these cases, so far unbreakable encoding techniques such as the 256-bit Advanced Encryption Standard should be used.'

Despite constraints and barriers – and sometimes because of them – new and innovative data links are taking to the air. **UV**

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A small world

Michael Drobac, executive director of the Small UAV Coalition, tells Tony Skinner about how advocates of small UAVs for commercial and civil operations are remaining confident in the face of crippling regulation and slow pace of reform.

The Small UAV Coalition was set up in the US to campaign for law and policy changes to permit the operation of small UAVs (SUAVs) beyond line of sight – with varying degrees of autonomy – for various purposes.

These include aerial photography and mapping, cost-effective advances in precision agriculture, fast and environmentally friendly consumer delivery, assistance to first responders in assessing disaster management and critical monitoring of oil and gas pipelines, among many other purposes.

TRANSFORMATIVE EFFECT

Drobac argues that SUAVs could potentially have a transformative effect on the US economy once proper regulatory reform is allowed to take place.

'The reality is that we don't view the FAA [Federal Aviation Administration] as the enemy on this – we understand the tremendous amount of pressure they are under to get this right and if anything we have sympathy for them with the tasks that they are facing,' he explained.

'But the problem is that doesn't mean you should be risk-adverse, it doesn't mean that you don't take chances and you don't really involve yourself in discovery and then be transparent with what you're discovering. And that's a problem we have with the FAA currently – there is nothing like the progress that we need to be making to compete with other nations.'

Drobac explained that in the FAA Modernization and Reform Act of 2012, the administration was instructed by Congress to come up with a new rule covering commercial SUAV operations.

'The current reality is that there is no US policy on UAVs for the commercial market. The FAA, which has the jurisdiction to control operations, hasn't responded to Congress in a timely fashion. In fact, that notice was supposed to come out and the rule completed by September 2015, but it will not be completed by then – it has not even been introduced yet and we know it's going to be highly prescriptive.

'The first thing is that there will be a notice of proposed rulemaking, which will be released some time in December or January, and after that point we are looking at somewhere between 16 and 24 months before we'll actually even have a rule that then operators can follow.'

OPEN MINDS NEEDED

While the FAA has been granted the authority to create exemptions within industry for operations, of the more than 80 petitions requesting them, only one has won approval.

This was awarded to six film production companies for aerial filming, but required them to produce safety manuals, ensure the locations were in a 'sterile environment' where everyone on set had approval to be there, a disaster management team was on standby and the UAVs could not go outside of line of sight.

Despite the slow pace of reform, Drobac remains upbeat, especially given that the coalition includes such industry heavy hitters as Airware, Amazon Prime Air, DJI Innovations, Google, GoPro, Parrot and 3DR helping to fight its corner.

'What's beautiful about this is that it is a world issue, which is going to be resolved by people that understand that you cannot stop technology that absolutely changes the way consumers live and that makes life better,' he argued.

'UAV technology is the next great technology – it really is. And to see the kind of support we're getting from the private sector is amazing. These are companies that are absolutely betting that this will be proved worldwide and they are betting on us to help get that message out.'

He noted that the key was in 'demystifying' the use of UAVs and making the public realise that 'drones' were of more use delivering a book or a pizza than a payload of weapons.

'There are reasonable concerns around many of these UAV issues, but those can be resolved through education or viewing the technology. And I think that's where we have the problem, which is that those in charge of allowing UAV operations are not close enough to the technology. And so that is what has to happen.'

Nevertheless, if US authorities do not become more proactive in driving reform, Drobac believes that companies will start to look elsewhere to further develop UAV technology.

'To put it bluntly there are much more open minds with other officials in other nations,' he concluded. 'The US has been a leader in technology for quite some time and other nations have seen that. Now, rather than doing what other countries have done in the past, which is not lead, they are leading. So the US now finds itself in the position of being behind, which is interesting.' UV

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